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INTERFACE REQUIREMENTS DOCUMENT (IRD)

FOR THE

GEOSTATIONARY OPERATIONAL ENVIRONMENTAL SATELLITE SERIES R (GOES-R) SYSTEM

SPACE SEGMENT (SS) TO GOES REBROADCAST (GRB) SERVICE

Document No. 417-SeriesR-IRD-0002

March 22, 2005

GOES-R PROJECT OFFICE
NASA GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

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SPACE SEGMENT (SS) TO GOES REBROADCAST (GRB) SERVICE

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1.0 INTRODUCTION

The Geostationary Operational Satellite System Series R (GOES-R) is an operational mission planned to make observations from geostationary orbit. The GOES-R mission will provide an Advanced Baseline Imager (ABI), Hyperspectral Environmental Suite (HES), Geostationary Lightning Mapper (GLM), Space Environmental In-Situ Suite (SEISS), Solar Imaging Suite (SIS) and auxiliary communication data product services described below. The GOES-R System will provide an expanded capability series of spacecraft to follow those developed and launched under the GOES N-Q Program. Five GOES-R Mission Segments interface and function to support the total GOES-R mission. They are (bold titles are items covered in this IRD):

- **Space Segment (SS)**
- Ground Located - Command, Control, and Communications Segment (GL-C3S)
- Product Generation and Distribution Segment (PGDS)
- User Interface Segment (UIS)
- Archive and Access Segment (AAS)

As part of the Space Segment (SS), the GOES-R will support the following communication data product services:

- **GOES Rebroadcast (GRB) Service**
- Low Rate Information Transmission (LRIT) Service
- Emergency Managers Weather Information Network (EMWIN) Service
- Data Collection System (DCS)
- Search and Rescue (SAR) Service

1.1 Purpose

The purpose of this document is to describe and specify the functional and performance interface requirements for the communication links between the GOES-R Space Segment (SS) and GRB Ground Terminals (GRBT) of the GRB data user community.

This document it also intended to provide a basis for the subsequent development of a SS-GRB Interface Control Document (ICD).

1.2 Scope

The interface supports the flow of data from the SS and to the GRB ground segments. The GRB transponder in the GOES-R Series spacecraft performs a conversion of the uplink X-band signal to the downlink L-band frequency. Only those parameters, which are necessary to specify the interface requirements, will be referenced here. Consequently, this IRD:

- Identifies required RF links between the SS and the GRB ground segments.
- Establishes functional and performance requirements related to the RF link between the SS and the GRB ground segments.

1.3 Applicable Documents

The following documents of the issue listed, or of the issue in effect on the effective date of the contract, form a part of this IRD to the extent specified herein. In the event of conflict between documents specified herein and other detailed content of this IRD, this IRD shall be the superseding requirement.

[1] Mission Requirements Document 2B (MRD-2B) for the GOES-R Series, Version 2.2 dated March 17, 2005.

[2] NOAA/NESDIS Antennas and RF System Capabilities Handbook, NOAA/OSD3-2001-0043R0UD0, 10 August 2001

[3] ITU Recommendation P.531-7 (4/03) titled Ionospheric Propagation Data and Prediction Methods Required for the Design of Satellite Services and Systems

[4] ITU-R P. 618-8 Propagation data and prediction methods for the design of Earth-space telecommunications systems

[5] ITU-R P. 837-4 Characteristics of precipitation for propagation modeling.

[6] ITU-R P. 876-5 Attenuation by atmospheric gases.

[7] ITU-R P. 839-3 Rain height model for prediction methods.

[8] ITU-R P. 838-2 Specific attenuation model for rain for use in prediction methods.

[9] ITU-R P. 581-2 The concept of the worst month.

[10] ITU-R P. 679-3 Propagation data required for the design of broadcasting-satellite systems.

[11] ITU-R P. 841-3 Conversion of annual statistics to worst-month statistics.

[12] ITU-R P. 531-7 Ionospheric propagation data and prediction methods required for the design of satellite services and systems.

[13] Intelsat Earth Station Standard (IESS) Document IESS-308 Rev 11, dated 31 January 2003

[14] International Telecommunications Union (ITU) Recommendation ITU-R RA 769-1 of the 1998 Edition of the ITU Regulations for Radio Astronomy

[15] ITU Article S21 of the ITU Radio Regulations RR-S21 in the 2001 Edition of the ITU Regulations for Power Flux Density Limits

[16] NTIA Manual of Regulations and Procedures for Federal Radio Frequency Management, May 2003 Edition, September 2004 Revision

Discussion: The ITU documents described in references [3] thru [12] can be used in determining propagation attenuation. Applicable document [12] is to be used for scintillation loss. The dash number used for each document is the updated release number. The ITU web site for the documents is http://www.itu.int/publibase/catalog/index.asp

2.0 GOES REBROADCAST (GRB) SERVICE AND INTERFACE DESCRIPTION

2.1 General Description

The GRB data service provides the GOES ground processed sensor data, other NWS products and related information to the weather research and Earth sciences community.

The GRB link relays the GOES processed sensor data independently through the GOES-East and GOES-West satellites, and downlinks the data to the Spacecraft Operation Control Center (SOCC) in Suitland, MD and other varied GRB users.

This system provides unidirectional broadcast link connectivity between the originating uplink from the NOAA Command and Data Acquisition Stations (CDAS) and a large number of outlying GRB Ground Terminals (GRBT) including NOAAs NWS and other research organizations. GRBT sites may be anywhere in the earth coverage area of the satellite out to a design minimum antenna elevation of 5° degrees.

The GOES-R satellites are located over the Atlantic and Pacific oceans at 75º and 135º [TBR] West Longitude to provide support to the GRBT and to the weather research and Earth sciences community.

The satellite GRB transponder is a bent-pipe architecture, i.e., receiving the uplinks within a certain frequency band, translating to a new frequency band, amplifying, and retransmitting on the downlink frequency. Each satellite employs an antenna for reception of the uplink GRB signal and an Earth coverage antenna to provide a downlink relay to the supporting ground stations.

2.1.1 Missing Requirements

This document contains all GRB RF interfaces except those labeled “TBD” and “TBR”. “TBD” (To Be Determined) means that the contractor should determine the missing requirement in coordination with the government. The Term “TBR” (To Be Reviewed) implies that the requirement is subject to review for appropriateness by the contractor or the government

2.1.2 Definitions

The statements in this document are not of equal importance. The word “shall” designates a requirement. Any deviations from requirements will require approval of the NASA contracting officer. The word “will” designates a statement of fact about the system, its operational environment or the intent of the government.

The word “threshold” is the minimum acceptable performance characteristic.

Rationale: MRD-2B, ID Item 1066

The word “goal” is an optimum level of performance, which, if met, could greatly enhance data utility.

Rationale: MRD-2B, Item 1067

3.0 GRB RF INTERFACE REQUIREMENTS

3.1 General Requirements

The GOES Re-Broadcast (GRB) transponder and RF data link shall support the processed data distribution from the CDAS to various receive sites including NOAA, NWS, DoD, international users, and research organizations.

Rationale: MRD-2B, ID Item 4429

The GRB data link requirements summary is described in Table 3.1-1.

CDA Uplink Tx	**Requirement**	**Rationale**
EIRP (dBm)	[TBD]	
Freq. (MHz)	7212.500 [TBR]	
Bandwidth (MHz)	12 [TBR]	MRD-2B ID Items 4436 and 4437
Polarization	dual circular polarized	Comm. working group recommendation
Data Rate	Para. 3.2.5	
Modulation	Para. 3.2.2	
FEC	Para 3.2.1	
Satellite Rx		
Polarization	dual circular polarized	Comm. working group recommendation
Antenna axial ratio	Para. 3.2.7	
Antenna Coverage	Para. 3.2.6	
Min. Rx G/T (dB/K)	[TBD]	
Dynamic Range	Nominal level +/- 5 dB	Comm. working group recommendation
Satellite Tx		
Frequency (MHz)	1690.200 [TBR]	MRD-2B ID Item 4438
Bandwidth (MHz)	1684.2-1696.2	Comm. working group recommendation
Polarization	dual circular polarized	Comm. working group recommendation
Polarization isolation (dB)	[TBD]	
EIRP (dBm)	[TBD]	
Antenna Coverage	Para. 3.3.1	
BER (may become FER)	1X 10^{-6} [threshold] at 99.9 % availability 1X 10^{-8} [goal] at 99.9 % availability	MRD-2B ID Item 4435
Ground Rx		
Polarization	dual circular polarized	Comm. working group recommendation
Min. Rx G/T (dB/K)	15.2	Heritage spec. from GOES-N,O,P
Rx System Loss (dB)	[TBD]	
Worst case antenna Elevation angle (degrees)	5	

Table 3.1-1 GRB Data Link Requirements Summary

3.2 Uplink Interface Requirements

3.2.1 Forward Error Correction Coding

A forward error correction (FEC) code such as Low Density Parity Check (LDPC) code will be used for the GRB uplink. The selection of a suitable FEC code will be coordinated with the needs of the data compression scheme, type of modulation used, etc. to ensure the best possible error free data throughput.

Rationale: Recommendation from Comm Working group

3.2.2 Modulation

The GRB uplink data modulations that are being considered include Gaussian Minimum Shift Keying (GMSK) with $\alpha = 0.5$ [TBR]. The selection of a suitable modulation will be coordinated with the needs of the data compression scheme, type of FEC used, etc. to ensure the best possible error free data throughput

Rationale: recommendation from Comm Working group

The proposed modulation concept will be compatible with commercial demodulator products.

Rationale: A commercial off-the-shelf demodulator design with demonstrated reliable performance is desired for operational convenience.

3.2.3 Frequency Drift

The CDAS uplink frequency drift will be maintained at ≤ 1 part in 10^9.

3.2.4 Phase Noise

The uplink phase noise will meet the mask given in Figure 3.2.4-1.

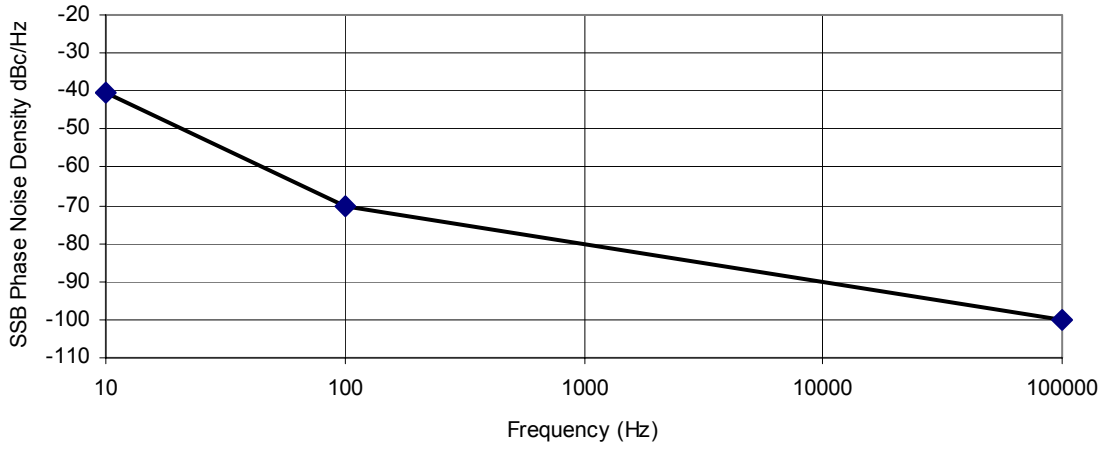

Figure 3.2.4-1 Phase Noise Specification

3.2.5 Data Rate

The threshold data rate for the GRB data link is 17 Mbps/s total including all overhead (TBR) and the data rate goal is 24 Mbits/s (TBR) including all overhead.

Rationale: MRD-2B, ID Item 4432.

Discussion: The transmission data rate will be a trade off between the expected data user needs which is presently estimated to be approximately 20 Mbps and a lower transmission data rate of approximately 17 Mbps that includes all overhead, and is easier to fit into the available 12 MHz available bandwidth with less risk.

3.2.6 Satellite Receive Antenna Coverage

The satellite receive antenna coverage shall be Earth hemisphere to a minimum ground antenna elevation angle of 5 degrees.

Rationale: MRD-2B ID Item 4439

3.2.7 Satellite Receive Antenna Axial Ratio

The satellite GRB receive antenna pattern axial ratio requirement is [TBD].

3.3 Downlink Interface Requirements

3.3.1 Satellite Transmit Antenna Coverage

The satellite transmit antenna coverage shall be Earth hemisphere to a minimum ground antenna elevation angle of 5 degrees.

Rationale: MRD-2B ID Item 4440

3.3.2 Phase Noise

The phase noise of the satellite transponder shall meet the mask given in figure 3.2.4-1.

3.3.3 Unwanted Radiation Mask

All communication links must comply with paragraph 5.2.2 for frequencies less than 470 MHz and 5.6.2 for frequencies above 470 MHz, of the NTIA Manual of Regulations and Procedures for Federal Radio Frequency Management, May 2003 Edition, September 2004 Revision.

Rationale: Communications working group recommendation.

3.3.4 Assumed Link Parameters

The specification for the items indicated below for the combined uplink and downlinks, i.e., for the full path between the CDAS antenna and the GRB user terminal, shall be provided by the contractor in the ICD.

1. The contractor shall provide the attenuation loss factors for rain and atmospheric attenuation loss based on the ITU models in applicable documents [2] through [11] for the CDAS and backup CDAS locations.

2. The contractor shall provide the loss factors for the worst case polarization mismatches on the uplink and downlink in the ICD.

3. The contractor shall provide the scintillation losses for the CDA and backup CDA stations as described in applicable document [11]. Scintillation losses for the data user ground stations shall be the responsibility of the GRB ground terminal, and it is their responsibility to ensure link closure after accounting of scintillation losses at their location.

4. Interference accesses shall be assumed to be small and no specific entry is required.

5. The worst- case end-of-life link margin requirement is 1 dB [TBR].

3.3.5 Radio Astronomy Band Protection

The EIRP value for the GRB downlink shall protect the radio astronomy band from 1660.0 to 1670.0 MHz, so that the spectral power flux density in this band at the surface of the earth shall be ≤ -266 dB W/m2-Hz.

Rationale: Compliance is required with the ;power flux density requirement for the Radio Astronomy band as described in the International Telecommunications Union (ITU) Recommendation ITU-R RA 769-1. The ITU specifies a maximum PFD at the ground of -251 dBW/m2/Hz for the RA band, and this level must be reduced by another 15 dB for geostationary satellites.

3.3.6 Power Flux Density Limit

The EIRP for the GRB downlink shall conform to the ITU regulations Section RRS21, Table S21-4 regarding Power Flux Density (PFD) at the surface of the Earth. The communications link shall comply for both the 1.5 MHz and 4 KHz bandwidth at L-Band.

The spacecraft contractor shall notify GSFC if he determines that any transmission channel requires a higher than allowed EIRP to meet the communications data link performance requirements.

The PFD values for each data transmission service shall be defined by the spacecraft contractor and incorporated into the Interface Control Document (ICD) following the Preliminary Design Review and after approval by GSFC.

Rationale: The ITU regulations are described in Article S21 titled “Terrestrial and Space Services Sharing Frequency Bands above 1 GHz” of the ITU Radio Regulation RR-S21.

3.4 LINK BUDGET REQUIREMENT

The spacecraft contractor shall provide the communication link budgets in the ICD for the GRB data links.

Changes to the link budgets shall be documented and reported monthly to the GSFC Communications Subsystem Manager.

Rationale: There is a need to ensure adequate link margins prior to and following the manufacturing of flight hardware.

APPENDIX A – ABBREVIATIONS AND ACRONYMS

ADS	Archive and Distribution Segment
ALC	Automatic Level Control
AM	Amplitude Modulation
AS	Archive Segment
β	Modulation Index
BCH	Bose-Chaudhuri-Hocquenghem (Forward Error Correction Code)
BER	Bit Error Rate
BPSK	Binary Phase Shift Keying
C3S	Command, Control and Communications Segment
CCSDS	Consultative Committee on Space Data Systems
CDA(S)	Command and Data Acquisition (Station)
C/N_0	Carrier to Noise Density Ratio (dB-Hz)
CWG	Communications Working Group
DCPI	Data Collection Platform Interrogate
DCPR	Data Collection Platform Report
DCS	Data Collection System
DMSP	Defense Meteorological Satellite Program
DSN	Deep Space Network
DSNUG	Deep Space Network Users Guide
EIRP	Equivalent Isotropically Radiated Power
EMWIN	Emergency Managers Weather Information Network
FEC	Forward Error Correction
GL-C3S	Ground Located - C3 Segment
GMSK	Gaussian Minimum Shift Keying
GPS	Global Positioning System
GRB	GOES Rebroadcast
GRBT	GRB Ground Terminal
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
G/T	Gain-to-Noise Temperature Ratio (dB/K)
HES	Hyperspectral Environmental Suite
HRD	High Rate Data

ICD	Interface Control Document
IDPS	Interface Data Processing Segment
IESS	Intelsat Earth Station Standard
IRD	Interface Requirements Document
ITU	International Telecommunications Union
L-Band	1 – 2 GHz Frequency Band
LDPC	Low Density Parity Check code
LEO	Low Earth Orbit
LRIT	Low Rate Information Transmission
LVL2	Level Two
MRD	Mission Requirement Document
NASA	National Aeronautics and Space Administration
NOAA	National Oceanographic and Atmospheric Administration
NPOESS	National Polar-Orbiting Operational Environmental Satellite System
NRZ-L	Non-Return to Zero – Level
NRZ-M	Non-Return to Zero – Mark
NTIA	National Telecommunications and Information Administration
OATS	Orbit & Altitude Tracking System
OQPSK	Offset QPSK (Also referred to as SQPSK – Staggered QPSK)
PCM	Pulse Code Modulation
PDR	Preliminary Design Review
PM	Phase Modulation
PSK	Phase Shift Keying
QPSK	Quadrature Phase Shift Keying (modulation)
RCT	Real-Time Critical Telemetry
RHST	Real-Time Health and Safety Telemetry
RHT	Real-Time Housekeeping Telemetry
RF	Radio Frequency
SAR	Search and Rescue
S-Band	2 – 4 GHz Frequency Band
SD	Sensor Data
SEISS	Space Environment In-Situ Suite
SIS	Solar Imaging Suite
SMD	Stored Mission Data
SOCC	Satellite Operations Control Center
SOH(T)	State of Health (Telemetry)
SQPSK	Staggered Quadrature Phase Shift Keying (Also called OQPSK)

SRS	Satellite Requirements Specification (GOES-R)
SS	Space Segment (synonymous with spacecraft)
TBD	To Be Determined
TBR	To Be Reviewed
TBS	To Be Supplied
TDRSS	NASA Tracking and Data Relay Satellite System
TRD	Technical Requirements Document
USG	United States Government
X-Band	8 – 12 GHZ Frequency Band